REMARKS

Prior to the present amendment, claims 21-34 were pending in the present application. By the present amendment, claims 21 and 28 have been amended. Thus, claims 21-34 remain in the present application. Reconsideration and allowance of pending claims 21-34 in view of the above amendments and the following remarks are requested.

A. Rejection of Claims 21-34 under 35 USC §103(a)

The Examiner has rejected claims 21-34 under 35 USC §103(a) as being unpatentable over U.S. patent application publication number 2005/0079696 to Luigi Colombo (hereinafter "Colombo") in view of U.S. patent number 6,265,260 to Alers et al. (hereinafter "Alers"), or U.S. patent no. 6,566, 250 to Tu et al. (hereinafter "Tu") as evidenced by U.S. patent application publication number 2004/0188240 to Chang et al. (hereinafter "Chang '240"), or U.S. patent number 6,090,210 to Ballance et al. (hereinafter "Ballance"), or U.S. patent number 6,759,337 to Aronowitz et al. (hereinafter "Aronowitz"), or U.S. patent application publication number 2005/0019964 to Chang et al. (hereinafter "Chang '964"). For the reasons discussed below, Applicants respectfully submit that the present invention, as defined by independent claims 21 and 28, is patentably distinguishable over the cited references, either singly or in any combination.

As disclosed in the present application, in an embodiment of the present invention, a nitridation process is performed on sidewalls 110 of gate stack 102

immediately after a gate etch process has been performed to form the gate stack. By performing the nitridation process after the gate etch process, the nitridation process can be utilized in the invention's process flow to repair damage that may occur to gate stack 102 during the etch process. During the nitridation process, nitrogen is introduced into high-k dielectric segment 106 and forms a barrier to prevent oxygen from laterally diffusing into high-k dielectric segment 106 during subsequent processing steps. Also, in an embodiment of the invention that utilizes an interfacial layer comprising nitride, the nitridation process can replace nitride that has been depleted in the interfacial layer during the gate etch process.

Additionally, independent claims 21 and 28 specify that the gate stack etch process and the nitridation process are performed in a single process chamber. By utilizing a single process chamber to perform the gate stack etch and nitridation processes, an embodiment of the invention avoids the need to break vacuum, thereby advantageously increasing throughput and reducing manufacturing costs.

Colombo is directed to encapsulation and conditioning structures and techniques for MOS transistor gates. *See*, e.g., Colombo, page 1, paragraph [0001]. In Colombo, a nitrided dielectric is provided between an encapsulation layer and the gate dielectric at the sidewall, and a nitrided material is provided between the encapsulation layer and the gate electrode at the sidewall. *See*, e.g., Colombo, page 1, paragraph [0010]. In Colombo, etch process 330 is performed to form a patterned gate structure with top and sidewall surfaces exposed, gate mask 328 is removed, implant mask 333 is formed, shallow drain

extension dopant implantation 334 is performed, a cleaning operation is optionally employed following implant 334, and then the sidewalls and top of the gate structure are nitrided via nitridation process 335. *See*, e.g., page 4, paragraphs [0028] and [0029] and Figures 5D through 5F of Colombo. Thus, in Colombo, a nitridation process is not performed immediately after etching a gate electrode layer and a high-k dielectric layer, as specified in independent claims 21 and 28.

Also, as acknowledged by the Examiner on page 3 of the Office Action of June 1, 2007, "Colombo is silent about using nitrogen-containing plasma for nitridating sidewalls." To overcome this deficiency, the Examiner has cited Alers and Tu to show a conventional nitridation method of applying plasma comprising nitrogen and has further stated that "it would have been obvious to one with ordinary skill in the art to apply said nitridation method in the process of Colombo in order to efficiently carry out the nitridation process." Page 3 of the Office Action of June 1, 2007.

However, Alers is directed to a method for making a capacitor including forming a first metal electrode including a tantalum pentoxide layer on a metal nitride surface and remote plasma annealing the tantalum pentoxide layer. *See*, e.g., Alers, column 1, line 62 through column 2, line 54. Also, Tu discloses performing a conventional nitridation step by exposing metal to a nitrogen containing plasma to form a metal nitride capping layer 20C so as to encapsulate a dual damascene structure with a metal nitride barrier. *See*, e.g., Tu, Column 6, lines 7-11. However, the structures disclosed in Alers and Tu are significantly different than transistor gate disclosed in Colombo. As such, Applicants

respectfully submit that, at the time the invention, as defined by independent claims 21 and 28 was made, a person of ordinary skill in the art would not have a sufficient reason to combine Alers and/or Tu with Colombo as suggested by the Examiner.

On page 4 of the Office Action of June 1, 2007, the Examiner also acknowledged that Colombo does not specify performing nitridation and etching in the same process chamber. However, the Examiner cites Chang '240, Ballanace, Aronowitz, and Chang '964 as evidence that "[i]t is common in the art that the plasma process chamber may be used for performing both etching and nitridation because it is efficient and more cost effective." Page 4 of the Office Action of June 1, 2007.

Chang '240 is directed to a process for the in-situ nitridation and formation of metal salicides. In Chang '240, the metal salicides are formed by utilizing a plasma generator. Ballanace discloses utilizing a "showerhead" for accomplishing a multi-zone gas flow control into a substrate in a process chamber. In Balance, a first gas distribution system delivers a first gas to a first subset of injection ports for injection into the chamber, and a second gas distribution system delivers a second gas to a second subset of injection ports for injection into the chamber. Aronowitz discloses a process wherein silicon oxide can be exposed to a nitrogen plasma in an etch chamber while applying an RF bias to a substrate support in the etch chamber to remove a uniform amount of the oxide, which was previously formed over a semiconductor substrate. Chang '964 discloses a method for determining a composition of an integrated circuit feature on a substrate, including collecting intensity data representative of spectral wavelengths of

radiant energy generated by a plasma during plasma nitridation of the integrated circuit feature on the substrate, and analyzing the intensity data to determine a peak intensity at one of the wavelengths.

However, the structures disclosed in Chang '240, Ballanace, Aronowitz, and Chang '968 are significantly different than the transistor gate disclosed in Colombo. As such, Applicants respectfully submit that, at the time the invention, as defined by independent claims 21 and 28 was made, a person of ordinary skill in the art would not have a sufficient reason to combine Chang '240, Ballanace, Aronowitz, and/or Chang '968 with Colombo as suggested by the Examiner.

For the foregoing reasons, Applicants respectfully submit that, at the time the invention defined by independent claims 21 and 28 was made, the invention would not have been obvious to a person of ordinary skill in the art by Colombo, Alers, Tu, Chang '240, Balance, Aronowitz, and Chang '964, either singly or in any combination thereof. Moreover, the fact that the Examiner has had to rely on a large number of references, i.e. seven (7) references, to argue for obviousness of the independent claims itself indicates that the pending independent claims are not obvious in light of the cited art.

B. Conclusion

For all the foregoing reasons pending claims 21-34 are patentably distinguishable over the cited art, and an early allowance of pending claims 21-34 is respectfully requested.

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Respectfully Submitted,
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